Title: Surface Area and Volume Ratios in Cells

Brief Overview:

This unit is an integration of important geometry, biology, and technology skills. The students will be using spreadsheet programs to solve problems relating surface area to volume ratios. Students will use cell models to observe the effect of increasing surface area to volume ratios on cell growth and functioning.

Links to NCTM Standards:

- **Mathematics as Problem Solving**
  Students will demonstrate the ability to use problem-solving approaches to investigate surface area and volume of cubes.

- **Mathematics as Communication**
  Students will communicate mathematical ideas about volume, surface area, and their ratios in a performance task assessment. The final lab report gives the opportunity for students to reflect and clarify what they have learned about volume, surface area, and their ratios.

- **Mathematics as Reasoning**
  Students will reinforce logical reasoning skills by comparing and contrasting different surface area to volume ratios.

- **Mathematical Connections**
  Students will use and value connections between mathematical topics and other disciplines.

- **Algebra**
  Students will be able to use tables and graphs as tools to interpret expressions and equations.

- **Functions**
  Students will model real-world phenomena with a variety of functions, and will represent and analyze relationships using tables, equations, and graphs.

- **Geometry from a Synthetic Perspective**
  Students will demonstrate the ability to interpret and draw 3 dimensional objects and represent problem situations by making geometric models.

- **Discrete Mathematics**
  Students will represent and analyze graphs and algorithms.

Links to Science Standards:

- **Processes of Science**
  Students will be able to describe observations and draw conclusions by collecting, organizing, and analyzing data.

- **Applications of Science**
  Students will describe to others how scientific information was used to solve problems and make decisions.

Links to Maryland High School Mathematics Core Learning Goals:

- **1.1.1**
  The student will recognize, describe, and extend patterns and functional relationships that are expressed numerically, algebraically, and geometrically.

- **1.1.2**
  The student will represent patterns and functional relationships in a table, as a graph, and/or by mathematical expression.

- **2.1.2**
  The student will identify and verify properties of geometric figures using concepts from algebra and using the coordinate plane.

- **2.3.2**
  The student will use techniques of measurement and will estimate, calculate, and compare perimeter, circumference, area, volume, and surface area of two-and-three-dimensional figures and their parts. The results will be expressed with appropriate precision.

- **3.1.1**
  The student will design and/or conduct an investigation that uses statistical methods to analyze data and communicate results.

Grade/Level:

Grades 9-12

Duration/Length:

Three to four ninety minute periods (variable)

Prerequisite Knowledge:

Students should have working knowledge of the following:

- Using a spreadsheet
- Constructing and comparing ratios
- Using formulas to determine the surface area and volume of a cube

Objectives:

Students will be able to

- compare increases in the volume of a cube with the increases in surface area as the length of a side increases.
- explain the relationship of volume and surface area of a cell to the diffusion of life-sustaining materials.
- use a spreadsheet to generate, display, and analyze numerical data.

Materials/Resources/Printed Materials:

Materials for Day 1:

- Nets (patterns) for cubes, tape, and scissors

- Lab materials (agar blocks, sodium hydroxide solution, 250 ml beakers, rulers, plastic spoon, plastic knife, paper towels: see Day 2 Activity 2 for more details)
- Lab direction and analysis sheet

Materials for Day 2:

- "Spreadsheet Introduction" Worksheet for students, Computers and spreadsheet program (Microsoft Works, etc.)
- Activity 2: "Observing Changing Areas in Rectangles with the Same Perimeters" Worksheet
- "Surface Area to Volume Ratio Using a Spreadsheet" Worksheet

Materials for Day 3:

- Assessment for unit
- Extension activities (optional)

Development/Procedures:

Time references will be for ninety-minute periods throughout this unit. During this unit students will use a spreadsheet program to compare increases in the volume and surface area of cubes as the length of a side increases. They will then explain the diffusion of materials through a cell in terms of the relationships that they observed. In the first class, students will work in groups of four to create different sized cubes from nets (patterns), in order to develop formulas and to relate surface area to volume in three-dimensional objects. After a brief introduction to cell biology, students will work with their groups to make observations of the diffusion of NaOH through agar cubes of varying sizes. They will then use their data to explore the relationship between surface area, cell volume, and diffusion of materials through cells. The second class will introduce spreadsheet use with an exercise for the students to plot the area of a square as the length of a side increases. Students will work with a partner to explore different types of graphs with the same data and investigate a perimeter/area maximization problem on the spreadsheet.

Extension/Follow Up:

Refer to following student extension exercise.

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Student Extension Exercise: Visualizing Changes

1. Imagine a perfect cube, 4 cm on each edge.

   a) What would be the surface area of that cube?

   b) What would be its volume?

   Suppose that cube is cut in half, forming two equal prisms.

   c) What would be the surface area of <u>each half</u>?

   d) What would be their <u>combined</u> surface area?

   e) What is the volume of each half?

   f) What is the total volume?

2. Imagine a perfect wooden cube, 5 cm on each edge.

   a) What would be the surface area of that cube?
   b) What would be the volume of the cube?

3. Suppose it is possible to cut out and remove a core from that cube. (The core would be one centimeter square on the top and bottom and five centimeters deep.) Now the coreless cube will be immersed in paint, so that every surface will be painted.

   a) What will be the area to be painted?

   b) What is the volume of the block now?

4. Imagine that you have a pile of 27 cubes, each one measuring 1 cm on each side. They must be arranged so that each cube has at least one side against the side of another cube (not just edges touching, or any other less-than-a-full-side contact).

   a) Sketch an arrangement that will have the greatest possible surface area.

   b) Sketch an arrangement that will have the least possible surface area.

5. Fred has noticed that jack rabbits found in desert areas have very long ears, while Arctic Hares have much shorter, rounder ears. He thinks the difference has to do with heat loss from surfaces. Expand upon his idea using what you know about the shape of an object and how that affects its area.

Day 1

Investigating Surface Area and Volume Using Cells
Student Response Sheet

Drill/Warm-up

1. Find the perimeter and area of a square with side length 2 cm.

2. Find the perimeter and area of a square with side length 4 cm.

3. Express all ratios in simplest form:
a. Find the ratio of the first side length to the second side length.
b. Find the ratio of the first perimeter to the second perimeter.
c. Find the ratio of the first area to the second area.

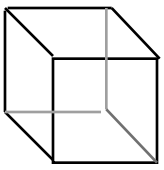
4. Mathematically, how does the ratio of the sides of the squares in numbers 1 and 2 relate to the ratio of their perimeters and to the ratio of their areas?

5. All squares are similar (congruent corresponding angles and proportional corresponding sides). Does your answer to problem 4 apply to all squares? Justify your answer by comparing the square in problem 1 with a square different from the square in problem 2. (Repeat the steps in problems 3 and 4 with the new square.)

6. Bonus: Rectangles are similar if their corresponding sides are proportional. For instance, a 2 cm by 3 cm rectangle is similar to a 4 cm by 6 cm rectangle because the ratio of their corresponding sides is 1:2 (it is in the same shape and with corresponding angles congruent). Does your answer to problem 4 still apply to these similar rectangles? Show the perimeter, area, and ratios to justify your answer.

Discovery of the formulas for surface area and volume of a cube.

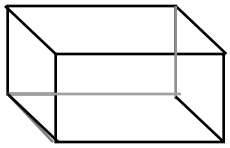
1. Look at this cube. Explain in words how to find the surface area for a cube. Use your explanation to write a formula.



2. Explain in words how to find the volume of a cube. Use your explanation to write a formula.

Bonus:

3. Look at this rectangular prism. Explain in words how to find its surface area. Use your explanation to write a formula.

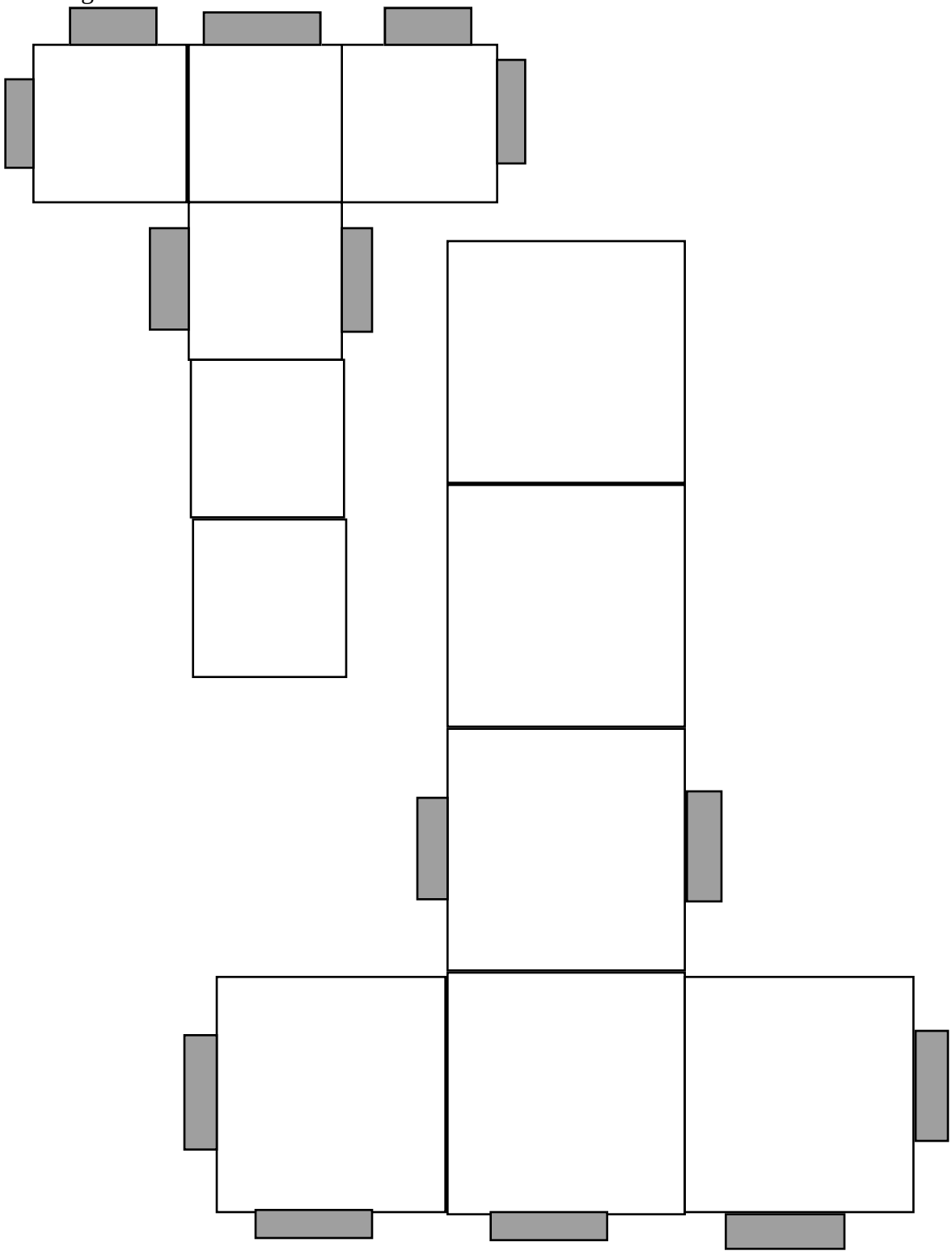


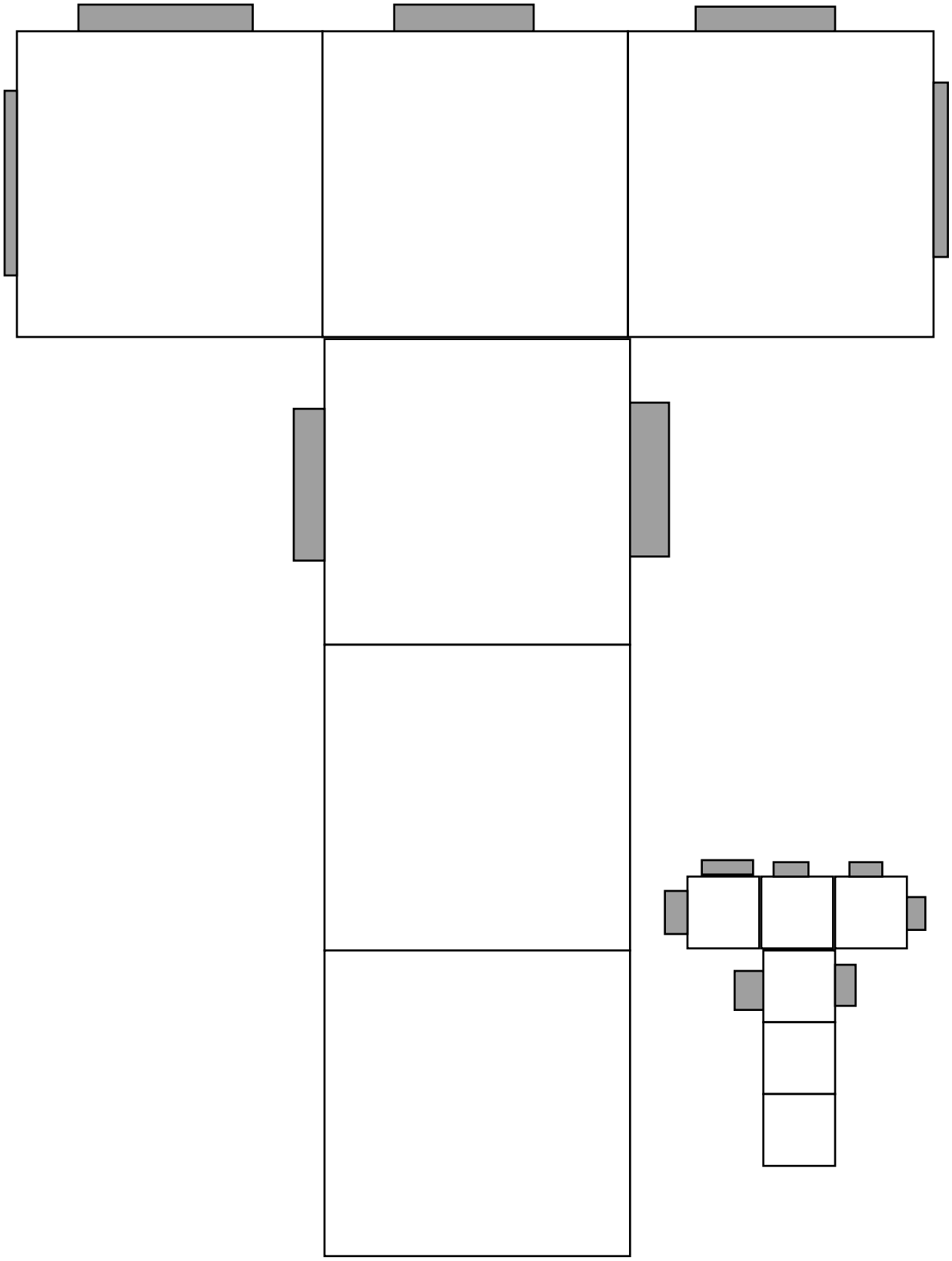
4. Explain in words how to find the volume of the prism. Use your explanation to write a formula.

Nets (Patterns) for Cubes

Activity 1

To explore the surface area and volume formulas for a cube, you are to cut out and tape the following two-dimensional versions of cubes into three-dimensional versions:





Now, using the formulas for surface area and volume of a cube, fill out the following for each of the cubes that you constructed:

	Side length	Surface Area	Volume
Cube 1	2 cm	_____	_____
Cube 2	4 cm	_____	_____
Cube 3	1 cm	_____	_____
Cube 4	3 cm	_____	_____

1. Compare the first cube to the second cube to find the following ratios (remember to always express ratios in simplest form): a. side lengths; b. surface areas; and c. volumes.

2. Compare the third cube to the fourth cube to find the following ratios (remember to always express ratios in simplest form): a. side lengths; b. surface areas; and c. volumes.

3. Compare the first cube to the fourth cube to find the following ratios: a. side lengths; b. surface areas; and c. volumes.

4. Use your results from numbers 1, 2, and 3 to generalize the ratios of side lengths, surface areas, and volumes you would expect for two cubes with side lengths a and b.

5. Bonus: Rectangular prisms are similar if their bases are similar and corresponding sides are proportional. For instance, a 1 cm by 2 cm by 3 cm rectangular prism is similar to a 2 cm by 4 cm by 6 rectangular prism because their bases are similar and the ratio of their corresponding sides is 1:2 (it is the same shape). Does your answer to problem 3 still apply to these similar rectangular prisms? Show the surface area, volumes, and ratios to justify your answer.

Day 1

TEACHER NOTES

Investigating Surface Area and Volume Using Cells

Drill/Warm-up

1. Find the perimeter and area of a square with side length 2 cm. **8 cm, 4 cm2**

2. Find the perimeter and area of a square with side length 4 cm. **16 cm, 16 cm2**

3. Find the ratio of the first side length to the second side length. Find the ratio of the first perimeter to the second perimeter. Find the ratio of the first area to the second area. **1:2, 1:2, 1:4**

4. How in a mathematical way does the ratio of the sides of the squares in numbers 1 and 2 relate to the ratio of their perimeters and to the ratio of their areas? **The ratio of the perimeters is the same as the ratio of the side lengths, but the ratio of the areas is to the square of the ratio of the side lengths. In symbols, side ratio a:b, perimeter ratio a:b, and area ratio $a^2 : b^2$.**

5. All squares are similar (congruent corresponding angles and proportional corresponding sides). Does your answer to problem 4 apply to all squares? **Yes, an example of this is a square with side length 6 cm compared to problem 1 with side ratio 1:3, perimeter ratio 1:3, and area ratio 1:9.**

6. Bonus: Rectangles are similar if their corresponding sides are proportional. For instance, a 2 cm by 3 cm rectangle is similar to a 4 cm by 6 cm rectangle because the ratio of their corresponding sides is 1:2 (it is in the same shape and with corresponding angles congruent). Does your answer to problem 4 still apply to these similar rectangles? Show the perimeter, area, and ratios to justify your answer. **Yes, side ratio 1:2, perimeter ratio 1:2, and area ratio 1:4.**

Discovery of the formulas for surface area and volume of a cube.

1. Look at this cube. Explain in words how to find the surface area for a cube. Use your explanation to write a formula.

sum of the areas of 6 identical squares
$S.A. = 6e^2$

2. Explain in words how to find the volume of a cube. Use your explanation to write a formula.

number of unit cubes that fill space inside
$V = e^3$

Bonus:

3. Look at this rectangular prism. Explain in words how to find its surface area. Use your explanation to write a formula.

Areas of 6 rectangles: front and back, top and bottom, left and right

$S.A. = 2(lw+lh+wh)$

4. Explain in words how to find the volume of the prism. Use your explanation to write a formula.

number of unit cubes that fill space inside
V = lwh

Activity 1: Nets (Patterns) For Cubes
TTT: Remind students to simplify all ratios.

To explore the surface area and volume formulas for a cube more, students are to cut out and tape the following two-dimensional nets of cubes into the three-dimensional versions:

Now, using the formulas for surface area and volume of a cube, fill out the following for each of the cubes that you constructed:

Side length	Surface Area	Volume
2 cm	**24 cm**	**8 cm**
4 cm	**96 cm**	**64 cm**
1 cm	**6 cm**	**1 cm**
3 cm	**54 cm**	**27 cm**

1. Compare the first cube to the second cube to find the following ratios: side lengths; surface areas; and volumes. **1:2, 1:4, 1:8**

2. Compare the third cube to the fourth cube to find the following ratios: side lengths; surface areas; and volumes. **1:3, 1:9, 1:27**

3. Compare the first cube to the fourth cube to find the following ratios: side lengths; surface areas; and volumes. **2:3, 4:9, 8:27**

4. Use your results from numbers 1, 2, and 3 to generalize the ratios of side lengths, surface areas, and volumes you would expect for two cubes with side lengths a and b. **The ratio of the surface areas is to the square of the ratio of the side length, and the ratio of the volumes is to the cube of the side length. In symbols, side ratio a:b, surface area ratio $a^2 : b^2$ and volume ratio $a^3:b^3$. An example of this is a cube with side length 8 cm compared to problem 1 with side ratio 1:4, surface area ratio 1:16, and volume ratio 1:64.**

5. Bonus: Rectangular prisms are similar if their bases are similar and corresponding sides are proportional. For instance, a 1 cm by 2 cm by 3 cm rectangular prism is similar to a 2 cm by 4 cm by 6 rectangular prism because their bases are similar and the ratio of their corresponding sides is 1:2 (it is in the same shape). Does your answer to problem 3 still apply to these similar rectangular prisms? Show the surface area, volumes, and ratios to justify your answer. **Yes, side ratio 1:2, surface area ratio 1:4, and volume ratio 1:8.**

Day 1

Activity: 2
Investigating Surface Area and Volume Using Cells

Cell Biology Background Information:

Approximately 100 trillion cells make up your body, so just imagine how small each cell actually is. If you were to line up 1000 of these cells, they would **total less than 2 cm in length**. Why can't cells continue to grow larger and larger? Is bigger better? Why are most cells, no matter what the size of the organism, microscopic in size? What happens when a cell grows larger and what causes it to divide?

These questions can be answered because of a process called diffusion. Diffusion is a major transport mechanism for moving substances into and out of the cell. Diffusion occurs passively (meaning that it does not require energy) through the cell membrane. Therefore, if cells were too large, they could not efficiently absorb materials or excrete wastes through the process of diffusion. If a cell doubled in size, it would require more nutrients and would have to excrete more waste. Otherwise, the lack of nutrients and build up of wastes would lead to cell death by starvation or poisoning. This investigation will allow you to observe the changing relationship of surface area - to - volume for a growing cell. In order to investigate this relationship we will be using agar blocks as models of cells.

Phenolphthalein is a biological indicator that reacts with a basic solution such as sodium hydroxide (NaOH). The phenolphthalein will turn pink when mixed with NaOH. The NaOH diffuses into the agar cubes at an equal rate for each cube, but because of differing volumes, the results will not appear the same.

Investigating Surface Area and Volume Using Cells

Materials: (per lab group)

- 1 cm^3, 2 cm^3, 3 cm^3 phenolphthalein agar blocks(see teacher sheet for preparation instructions)
- 100 ml of 0.4% sodium hydroxide (avoid contact with skin or eyes)
- 250 ml beaker
- mm ruler
- plastic knife
- plastic spoon
- paper towel

Procedure: (Part A)

1. Pick up three agar cubes(1 of each size- 1 cm3, 2 cm3, 3 cm3) Think of the cubes as large models of microscopic cells.
2. Place the cubes in the beaker and pour in enough NaOH to cover them.
3. Allow the setup to stand for the next 10 minutes. During this time be sure to occasionally swirl the NaOH solution but be careful not to scratch or cut the surface of the cubes.
4. While you are waiting for results in part A, answer the questions listed under Discussion 1.

Discussion 1:

1. If the pink color represents food, which of your 3 model cells do you think would be getting the best food supply? Explain.

_____
_____
_____
_____

2. Do you think that the cell with the greatest total surface area will do the best job of moving material in and out of the cell? Explain.

_____
_____
_____
_____

3a. Calculate the total surface area of each of your 3 models.

1 cm _____ 2 cm_____
3 cm _____

3b. Which cell has the greatest surface area? _____

4a. Calculate the volume of each cube.

1 cm _____ 2 cm _____
3 cm _____

4b. Do these calculations change your answer to question #2? Why or why not?

_____
_____
_____
_____
_____
_____

Procedure: (Part B)

1. At the end of 10 minutes, take your beaker to the sink. Carefully pour off the NaOH solution and rinse the agar cubes with water. Using plastic spoons, remove the agar cubes from the beaker, place them on a paper towel and blot them dry.
2. Using a plastic knife, cut the cubes in half and examine and compare their inside appearance. Using the mm ruler, measure the depth of the colored zones for each cube and record your data. Sketch each cube to show the color changes.
3. After you have made your observations and recorded your data, be sure to clean up your lab area and properly dispose of your agar cubes.

Data:

1. 1 cm cube (Sketch to show color change.)

Depth of color change:_____

2. 2 cm cube (Sketch to show color change.)

Depth of color change:_____

3. 3 cm cube (Sketch to show color change.)

Depth of color change:_____

Discussion #2

1. Anything that the cell takes in , like oxygen and food, or lets out, such as carbon dioxide, must go through the cell membrane. Which geometric calculation best represents how much cell membrane the models have?

_____
_____
_____

2. What similarities did you notice when you measured the colored zone of each cube?

_____
_____
_____

3. As the cell grows larger and gets more cell content, will it need more or less cell membrane to survive? _____

_____
_____

4. How do your observations and calculations relate to the questions of why cells are usually very small? _____

_____
_____
_____

Day 1

Teacher Notes
Activity: 2
Investigating Surface Area and Volume Using Cells

Cell Biology Background Information:

Approximately 100 trillion cells make up your body, so just imagine how small each cell actually is. If you were to line up 1000 of these cells, they would **total less than 2 cm in length**. Why can't cells continue to grow larger and larger? Is bigger better? Why are most cells, no matter what the size of the organism, microscopic in size? What happens when a cell grows larger and what causes it to divide?

These questions can be answered because of a process called diffusion. Diffusion is a major transport mechanism for moving substances into and out of the cell. Diffusion occurs passively (meaning that it does not require energy) through the cell membrane. Therefore, if cells were too large, they could not efficiently absorb materials or excrete wastes through the process of diffusion. If a cell doubled in size, it would require more nutrients and would have to excrete more waste. Otherwise, the lack of nutrients and build up of wastes would lead to cell death by starvation or poisoning. This investigation will allow you to observe the changing relationship of surface area - to - volume for a growing cell. In order to investigate this relationship we will be using agar blocks as models of cells.

Phenolphthalein is a biological indicator that reacts with a basic solution such as sodium hydroxide (NaOH). The phenolphthalein will turn pink when mixed with NaOH. The NaOH diffuses into the agar cubes at an **equal rate for each cube**, but because of differing volumes, the results will not appear the same.

**** If you are not going to conduct the experiment, you can still use the following information to complete the rest of the activity with the exception of altering a few discussion questions.

When students cut into the agar cubes, the center will not have picked up the stain. This indicates that the NaOH will not have diffused all the way through the block. The larger the block of agar, the greater the unstained area. In the lab you would see that the NaOH stain(pink) is the same thickness for all three cells, but you would also observe that the large cell still has a large region in the center that did not turn pink. This then indicates the importance of cell size in the diffusion of substance.

Investigating Surface Area and Volume Using Cells

Materials: (per lab group)

- 1 cm^3, 2 cm^3, 3 cm^3 phenolphthalein agar blocks(to make this you will need to mix 20g agar with 1 L of water. Bring this to a boil, stirring continuously. Let the mixture cool, but before it solidifies add 1g phenolphthalein powder for each liter of water. If the mixture is pink, ad a few drops of dilute HCL until the pink disappears. Pour mixture into a rectangular flat pan that is a little over 3 cm deep. Once it has solidified, cut the agar into 1x1x1, 2x2x2, 3x3x3 blocks.)
- 100 ml of 0.4% sodium hydroxide (To Make, add 4 g NaOH to 1000 ml distilled water)
- 250 ml beaker

- mm ruler
- plastic knife
- plastic spoon
- paper towel

Procedure: (Part A)

1. Pick up three agar cubes(1 of each size- 1 cm3, 2 cm3, 3 cm3) Think of the cubes as large models of microscopic cells.
2. Place the cubes in the beaker and pour in enough NaOH to cover them.
3. Allow the setup to stand for the next 10 minutes. During this time be sure to occasionally swirl the NaOH solution but be careful not to scratch or cut the surface of the cubes.

Discussion 1:

1. If the pink color represents food, which of your 3 model cells do you think would be getting the best food supply? Explain. **Any defendable hypothesis is acceptable**

2. Do you think that the cell with the greatest total surface area will do the best job of moving material in and out of the cell? Explain?
Yes. Materials move in and out of the cell through the surface or membrane

3a. Calculate the total surface area of each of your 3 models.

1 cm = **6 cm^2** 2 cm = **24 cm^2**
3 cm = **54 cm^2**

3b. Which cell has the greatest surface area? **3 cm -cube**

4a. Calculate the volume of each cube.

1 cm = **1 cm3** 2 cm = **8 cm^3**
3 cm = **27 cm3**

4b. Do these calculations change your answer to question #2? Why or why not?
Students may modify predictions depending on their initial hypothesis.

Procedure: (Part B)

1. At the end of 10 minutes, take your beaker to the sink. Carefully pour off the NaOH solution and rinse the agar cubes with water. Using plastic spoons, remove the agar cubes from the beaker, place them on a paper towel and blot them dry.
2. Using a plastic knife, cut the cubes in half and examine and compare their inside appearance. Using the mm ruler, measure the outer colored zones of each cube and record your data.
3. After you have made your observations and recorded your data, be sure to clean up your lab area and properly dispose of your agar cubes.

Discussion #2

1. Anything that the cell takes in , like oxygen and food, or lets out, such as carbon dioxide, must go through the cell membrane. Which geometric calculation best represents how much cell membrane the models have? **Total Surface Area**

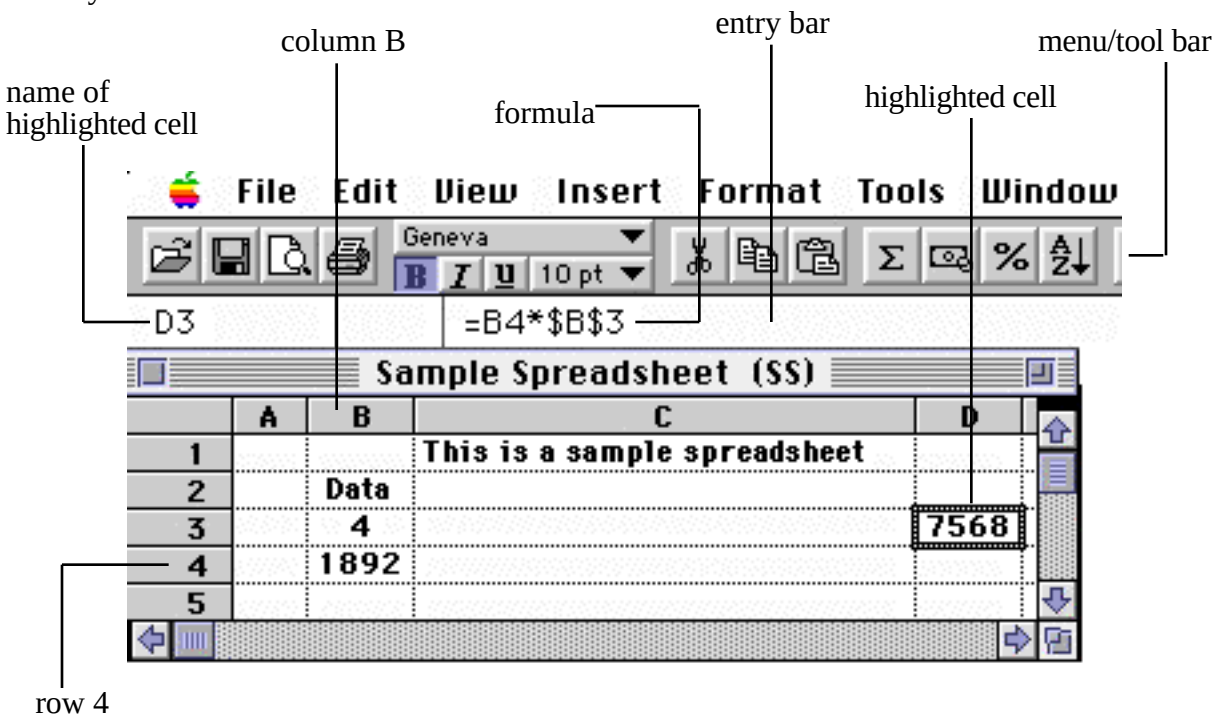
2. What similarities did you notice when you measured the colored zone of each cube?
The pink zone is the same thickness on all cubes

3. As the cell grows larger and gets more cell content, will it need more or less cell membrane to survive?
The cell needs more membrane in order to provide greater area for intake of oxygen and food and release of waste.

4. How do your observations and calculations relate to the questions of why cells are usually very small?
Small cells usually have a greater surface-area- to - volume ratio.

Student Response Sheet
Introduction to Spreadsheets

Activity 3:



1. Each cell of a spreadsheet may contain one of the following types of information.
   Text: "This is a sample spreadsheet "
   Numbers: "1892"
   Formulas: "=B4$B$3"

2. The letters name the columns. The numbers name the rows

Q1. Identify a cell that displays text. _____

3. Always start a formula with "=" (Do not type the quotes). You must follow the order of operations.

Q2. Identify a cell that uses a formula. _____

4. There are two types of cell references: relative and absolute.
   Relative Reference: automatically adjusts cell reference
   Absolute Reference: identifies a specific cell using "$"

Q3. Identify the part of the formula that is a relative reference. _____

Q4. Identify the part of the formula that is an absolute reference. _____

5. Highlight the data you would like in the chart/graph
   Use the **make a chart** feature
   Charts will automatically update as the data is changed

Example 1: Absolute and Relative References

Note: " " indicates information to be typed into the entry bar . Hitting the return/enter key will display the value in the appropriate cell.

Relative References:

In cell [A1] type "2"

In cell [B1] type "=A1+1" (This is a formula. Clicking on cell [A1] will place it in the formula.)

Highlight cells [B1] through [F1]. From the **Edit** menu, choose the fill across (or fill right) option. (This replicates or copies the formula to the other cells.)

Q1. Place the cursor on cell [C1], [D1]. What do notice about the replicated formula?

_____

_____

In cell [A2] type "=A1+3"

Highlight [A2] through [A6]. Choose the fill down option from the **Edit** menu.

Q2. Place the cursor on cell [A3]. How do the changes in the replicated formula differ from the changes in Q1?

_____

_____

Absolute References:

In cell [B2] type "=$A$2*B1" (The $ makes the information an absolute reference. It will not adjust.)

Highlight [B2] through [B6] and fill right (across).

Q3. Look at the formulas of these new cells. Compare what has happened to the two different types of cell references.

_____

_____

Example 2: Perimeter and Area of a Rectangle

Type the following text in these cells:
[A1] Base [B1] Height [C1] Perimeter [D1] Area

Adjust the column size by placing the cursor in the gray area on the line between any two columns then drag the cursor until the column width fits the heading.

Determine the spreadsheet formulas for perimeter and area of a rectangle.

perimeter_____ area_____

Enter the data shown below:

	A	B	C	D
1	Base	Height	Perimeter	Area
2	1	3		
3	3	3		
4	5	3		
5	7	3		
6	9	3		

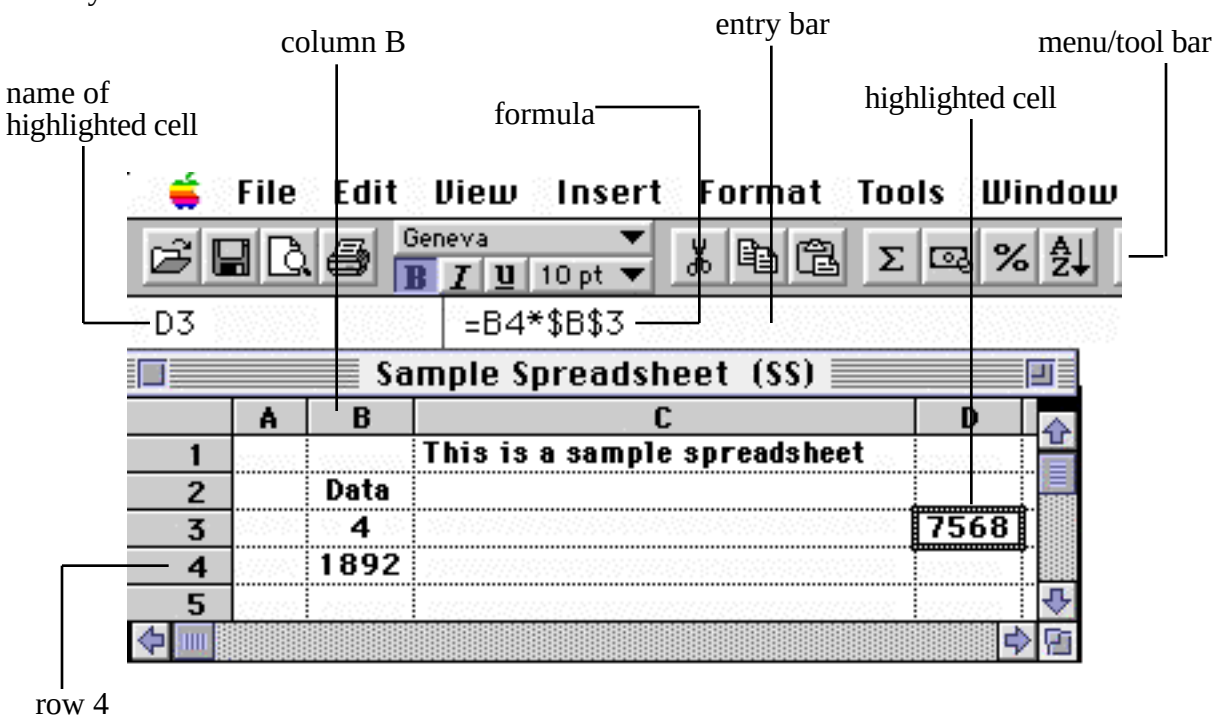
In [C2] type the spreadsheet formula for perimeter then fill down.

In [D2] type the spreadsheet formula for area then fill down.

Q1. Create a line graph comparing the perimeter and area as the length of the base increases.

Teacher Notes
Introduction to Spreadsheets

Activity 3:



1. Each cell of a spreadsheet may contain one of the following types of information.
   Text: "This is a sample spreadsheet "
   Numbers: "1892"
   Formulas: "=B4$B$3"

2. The letters name the columns. The numbers name the rows

Q1. Identify a cell that displays text. [C1] or [B2]

3. Always start a formula with "=" (Do not type the quotes). You must follow the order of operations. (**To the Teacher**: There is a list of predefined functions)

Q2. Identify a cell that uses a formula. [D3]

4. There are two types of cell references: relative and absolute.
   Relative Reference: automatically adjusts cell reference
   Absolute Reference: identifies a specific cell using "$"
   (**TTT**: You can make reference to a cell in your formula by clicking on that cell.)

Q3. Identify the part of the formula that is a relative reference. B4

Q4. Identify the part of the formula that is an absolute reference. $B$3

5. Highlight the data you would like in the chart/graph
   Use the **make a chart** feature
   Charts will automatically update as the data is changed
   (**TTT**: You must address chart making that is specific to the spreadsheet software you are using.)

Example 1: Absolute and Relative References

Note: " " indicates information to be typed into the entry bar. Hitting the return/enter key will display the value in the appropriate cell.

Relative References:

In cell [A1] type "2"

In cell [B1] type "=A1+1" (This is a formula. Clicking on cell [A1] will place it in the formula.)

Highlight cells [B1] through [F1]. From the **Edit** menu, choose the fill across (or fill right) option. (This replicates or copies the formula to the other cells.)

Q1. Place the cursor on cell [C1], [D1]. What do notice about the replicated formula?

A1. Notice the replicated formula adjusted the column letter so that the formula automatically refers to the previous cell (on the left).

In cell [A2] type "=A1+3"

Highlight [A2] through [A6]. Choose the fill down option from the **Edit** menu.

Q2. Place the cursor on cell [A3]. How do the changes in the replicated formula differ from the changes in Q1?

A2. Notice the replicated formula adjusted the row number so that the formula automatically refers to the previous cell (above).

Absolute References:

In cell [B2] type "=$A$2*B1" (The $ makes the information an absolute reference. It will not adjust.)

Highlight [B2] through [B6] and fill right (across).

Q3. Look at the formulas of these new cells. Compare what has happened to What do you notice?

A3. Notice the $A$2 part of the formula remained constant while the B1 portion adjusted relative to the previous cell.

TTT: Resulting spreadsheet with values:

	A	B	C	D
1	2	3	4	5
2	5	15	20	25
3	8			
4	11			
5	14			

with formulas:

	A	B	C
1	2	=A1+1	=B1+1
2	=A1+3	=$A$2*B1	=$A$2*C1
3	=A2+3		
4	=A3+3		

Example 2: Perimeter and Area of a Rectangle

Type the following text in these cells:
[A1] Base [B1] Height [C1] Perimeter [D1] Area

Adjust the column size by placing the cursor in the gray area on the line between any two columns then drag the cursor until the column width fits the heading.

Determine the spreadsheet formulas for perimeter and area of a rectangle.

perimeter "=2*A2+2*B2" area "=A2*B2"

Enter the data shown below:

	A	B	C	D
1	Base	Height	Perimeter	Area
2	1	3		
3	3	3		
4	5	3		
5	7	3		
6	9	3		

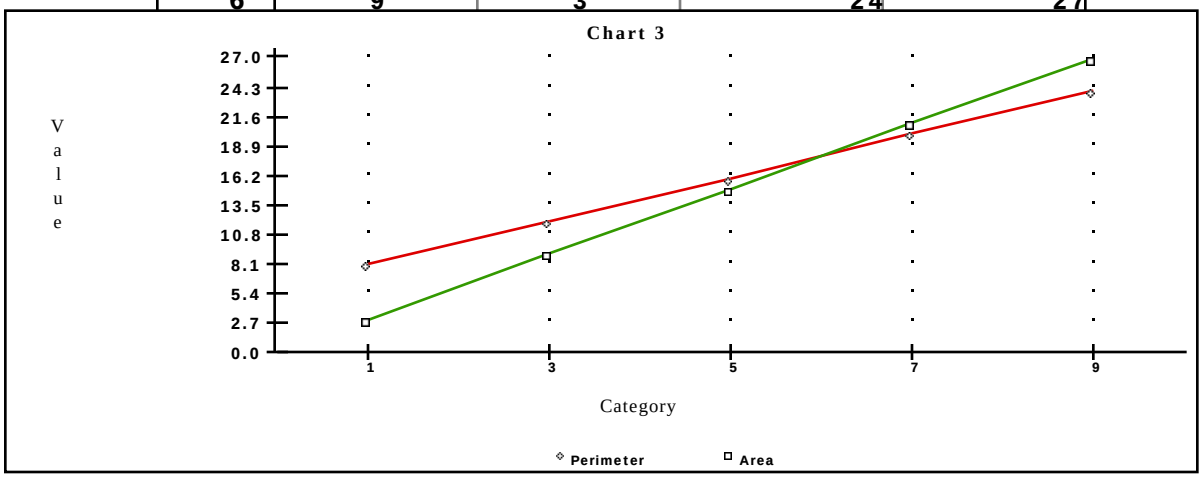
In [C2] type the spreadsheet formula for perimeter then fill down.

In [D2] type the spreadsheet formula for area then fill down.

Q1. Create a line graph comparing the perimeter and area as the length of the base increases.

TTT: Resulting spreadsheet and chart:

	A	B	C	D
1	Base	Height	Perimeter	Area
2	1	3	8	3
3	3	3	12	9
4	5	3	16	15
5	7	3	20	21
6	9	3	24	27



Teacher Resource

Exploring Surface Area and Volume Using Cells

Activity 4: Observing Changing Areas in Rectangles with the Same Perimeters

Objective: Be able to explain the relationship between the shape of rectangles of a given perimeter and the area of those rectangles.

Materials: Activity 4 Student Spreadsheet, Spreadsheet Program such as Microsoft Works

Preparation:

1. Have students suggest measurements for rectangles with the same areas but different sides.
(If A = 12 sq.cm., b=6 and h=2, b= 3 and h = 4, etc.)

2. Have students suggest measurements for rectangles with the same perimeter but different sides. (P=12, b = 5 and h = 1, b = 2 and h = 4, etc.)

3. Students will now use a spreadsheet to explore the **area** changes in rectangles with the same perimeters but differing heights and bases.

Designing the Spreadsheet:

1. Following the suggestions on the Student Spreadsheet Sample, students will write a title (Different Areas of Rectangles with the Same Perimeters), identify variables, and write formulas for area and perimeter. (The second spreadsheet on the page is a spare in case of messy errors.)

2. Discuss with students how to have the spreadsheet calculate the area for different rectangles with the same perimeter.

i.e: A = bh
If P = 20, then h + b = 10
If h + b = 10, then h = 10 - b, so we can calculate **h** from **b**.

3. It should be apparent at this point that the column headings on the spreadsheet will be "Base", "Height", and "Area". Students should write those headings under "Heading 1", "Heading 2", and "Heading 3" on the Student Spreadsheet Sample.

4. (Pairs suggested here.) For this calculation, let P = 24. Students should discuss numbers to use for the base length, then the formula to calculate the height for each base measure. Finally, they should write the appropriate area formula for that column. Discuss student conclusions and correct if necessary.

5. Students should now enter information on their spreadsheets and check the "Areas" column for realistic answers.

	A	B	C	D
1	Title: Different Areas of Rectangles w			
2				
3	Variables: P = perimeter, A = Area			
4				
5	Formulas: P = 2h + 2b		A = bh	
6				
7	Heading 1(Base)	Heading 2 (Height)	Heading 3(Area)	
8	1	12-A7	A7*B7	

6. Students should then create a chart of the information (Tools menu). Discuss the shape of the graph, encouraging observations on the greatest possible area for the given perimeter. (Some exploration of different graph types is in order here as time allows.)

Teacher Resource

Exploring Surface Area and Volume Using Cells

Activity 5: Comparing Changes in Surface Area and Volume of Cells

Objective: Use a spreadsheet to calculate and examine the Surface Area -to-Volume ratio.

Materials: Activity 5 Student Spreadsheet, Surface area and volume data from Activity 2 lab investigation, Spreadsheet Program such as Microsoft Works

Designing the Spreadsheet:

1. Using the spreadsheet from activity 4 as a model, students will write the formulas they will need on the Activity 5 Student Spreadsheet and decide how to best calculate and display their data.

2. Students will then choose the column arrangement and headings they will use.

3. The first data will be from the Activity 2 lab investigation. That data will be used to calculate surface area, cell volume, and the Surface Area-to-Volume ratio. Once that has been calculated and displayed in a satisfactory form on a graph, students will be able to investigate SA to V relationships when the cells are much smaller or much larger.

	A	B	C	D	E
1		Title:			
2					
3	Variables:				
4					
5	Formulas:				
6					
7	Heading 1	Heading 2	Heading 3...		
8					
9					
10					
11					
12					

Using your graph and spreadsheet answer the following questions:

1. As the cell grows larger, does the Total Surface Area- to - Volume Ratio get larger, smaller, or remain the same? **The ratio decreases**

2. Why can't cells survive when the Total Surface Area - to - Volume ratio becomes too small? **The greater cell content needs more oxygen and food than the membrane can take in and produces more waste than the membrane can release.**

3. What is the Surface Area to Volume ratio for a cell that is 0.1 cm^3?
Surface Area = .06 cm2
Volume = .001 cm^3
Surface Area to Volume Ratio = 60:1

4. What predictions can you make about the cell model in question 3?
High Surface Area to Volume Ratio would make this cell very efficient.

Investigating Surface Area and Volume Using Cells
Assessment Activity
Teacher's Guide

Introduction:

The purpose of the Assessment Activity is to provide feedback to you so that appropriate instructional decisions can be made. The task assess application of objectives included in the Geometry and Biology curriculum guides relating surface area, volume and cell size. This activity also asses the students ability to properly operate a spreadsheet program.

Objectives Covered: This task assumes that your students have received instruction and have been assessed on the following concepts and/or objectives:

- compare changes in the volume of a cube with the changes in surface area as the length of a side increase or decreases
- use formulas to determine values of surface area and volume of various 3-dimensional objects
- Use a spreadsheet program to enter, graph and analyze data in order to draw a conclusion
- Relate the relationship of volume and surface area of a cell to the diffusion of life sustaining materials

Tools/Materials Needed for Assessment:

Per student: Copy of task, and pencil

Administering the Assessment:

This task should take approximately 30-45 minutes to administer

Distribute the necessary materials to each student

SAY: For this period, you are going to use the things that you have learned this week to independently complete the following task. Read through the assessment activity at this time to see if you have any questions or problems.

Pause and allow students to read silently.

SAY: Are there any questions? You may begin.

Assessment
Student Response Sheet

Short Response

1. The surface area of a cube with side length 2.5 cm is:

   A. 15.63 cm^2 B. 37.50 cm^2
   C. 7.50 cm^2 D. 25.00 cm^2

2. The volume of a cube with side length 2.5 cm is:

   A. 15.63 cm^2 B. 37.50 cm^2
   C. 7.50 cm^2 D. 25.00 cm^2

3. Which surface area to volume ratio is the largest?

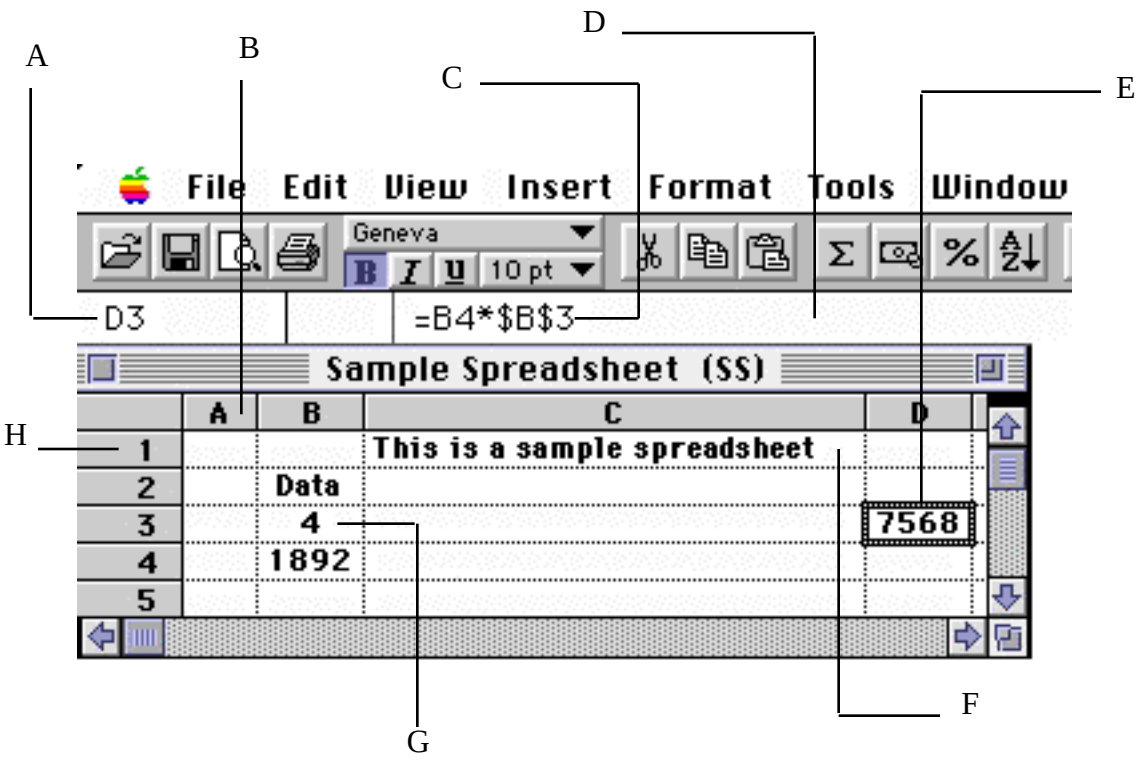
   A. 467/528 B. 382/402
   C. 456/444 D. 105/107

Brief constructed Response

1. Formulas in a spreadsheet must always start with a (an) _____ _____.

2. Why are there no unicellular (1 celled) organisms 30 mm in diameter?
_____
_____
_____
_____

3. Keeping in mind surface area to volume ratio, why do you think it would take less time to digest food that is well chewed?
_____
_____
_____
_____
_____



Word List:

formula	row name	highlighted cell
entry bar	tool bar	name of highlighted cell
column name	text cell	data cell

Using the diagram and word list above, give the name of the part labeled by the following letters:

A. _____ B. _____

C. _____ D. _____

E. _____ F. _____

G. _____ H. _____

Extended Response 1.

Explorers who have recently landed on an earth-like planet have discovered a common unicellular life form. Their excited report has been somewhat garbled in transmission. Information that was clear said that the unicellular organisms weighed several kilograms each and were capable of slow but steady movement. Pictures and detailed descriptions were scrambled hopelessly, however.

From what you know about the needs of a cell and the effects of size on both volume and surface area, propose one or more possible shapes for the life forms. Also consider and describe advantages and disadvantages of that proposed shape for the life of the organism.

Extended Response 2.

Using the available spreadsheet program, construct a spreadsheet comparing surface area to volume as the size of the sphere changes.

After completing your spreadsheet create a line graph of your data.

Describe and compare the change in surface area and in volume as the radius increases.

Assessment
Scoring Guide

Short Response

1. The surface area of a cube with side length 2.5 cm is:

   A. 15.63 cm^2 **B. 37.50 cm^2**
   C. 7.50 cm^2 D. 25.00 cm^2

2. The volume of a cube with side length 2.5 cm is:

   A. 15.63 cm^2 B. 37.50 cm^2
   C. 7.50 cm^2 D. 25.00 cm^2

3. Which surface area to volume ratio is the largest?

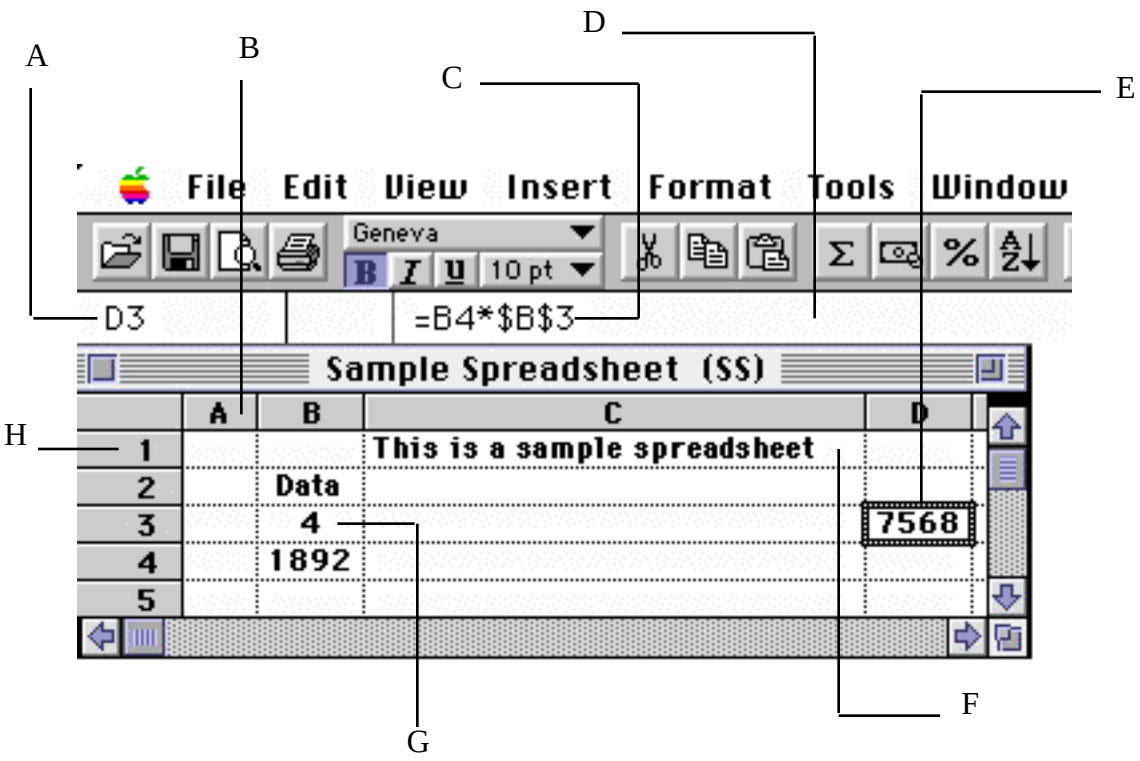
   A. 467/528 B. 382/402
   C. 456/444 D. 105/107

Brief constructed Response

1. Formulas in a spreadsheet must always start with a (an) **equal sign**

2. Why are there no unicellular (1 celled) organisms 30 mm in diameter?
   Because the larger the organism ,the smaller the surface area - to - volume ratio; therefore the cell could not receive adequate nutrients

3. Keeping in mind surface area to volume ratio, why do you think it would take less time to digest food that is well chewed?
   Chewing the food breaks it up so that a larger surface area is exposed to the digestive enzymes.



Word List:

formula	row name	highlighted cell
entry bar	tool bar	name of highlighted cell
column name	text cell	data cell

Using the diagram and word list above, give the name of the part labeled by the following letters:

A. _____ B. _____

C. _____ D. _____

E. _____ F. _____

G. _____ H. _____

Explaining Surface Area and Volume Ratios in Cells: Rubric for the extension on the sphere spreadsheet

Criterion Points	Achieved	Making progress	Not met	Points
Spreadsheet Mathematical representation	evidence of and correct use of text, numbers, formulas, and references; functions correctly used; efficient layout and design	some errors in use of text, numbers, formulas or references	incorrect use of functions, tools, or references	_____
Presentation	numbers appropriately formatted; labels, units and titles included; visually appealing; correct spelling and grammar	titles, labels or units missing OR major flaws that do not affect the function of the spreadsheet	poor choice of layout that makes the data and calculations hard to read	_____
Graphs				
Visual representation	graph is appropriate for data		inappropriate choice of graph	_____
Numerical input	appropriate selection of data subset; scales appropriate; multi-set data correctly selected	incomplete selection of data sets OR poor choice of scaling factors	inappropriate selection of data to graph	_____
Presentation	visually appealing; appropriate use of labels, titles, and legends; spelling and grammar correct		labels, legends and titles missing, making the graph hard to interpret	_____

Activity 1

Formulas for Activity 1 Spreadsheet

SideLength	SurfaceArea	Volume	SA toVol
	6*A2*A2	A2^3	B2/C2